TECHNICAL REPORT
71-26-FL

EFFECT OF MOISTURE ON THE QUALITY OF FREEZE-DRIED SPAGHETTI WITH MEAT SAUCE

by
J. M. Tuomy
and
Larry Hinnergardt

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UNITED STATES ARMY
NATICK LABORATORIES
Natick, Massachusetts 01760

Food Laboratory
FL-122

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71-26-7B-FL

EFFECT OF MOISTURE ON THE QUALITY OF FREEZE-DRIED SPAGHETTI WITH MEAT SAUCE

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J. M. Tuomy and L. C. Hinnergardt

Project reference:
1J662708D553

Series: FL - 122

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Food Laboratory
U.S. ARMY NATICK LABORATORIES
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FOREWORD

The main components in the Food Packet, Long Range Patrol are dried as complete items rather than as separate ingredients. Thus, they represent a new family of freeze-dried combination foods in the Armed Services ration system. This study was conducted to obtain more knowledge on the effects of moisture level in this type of food.

The adverse effects of moisture on freeze-dried foods has been recognized from the beginnings of the Armed Forces program to develop freeze-dried rations. Considerable work was done on relating optimum moisture content to the theoretical monomolecular layer of absorbed water. Some work has been done on storage studies of products with elevated moistures. However, no work has been done on components of the Food Packet, Long Range Patrol.

The work was performed under project 1J6-62708-D553, Food Processing and Preservation Techniques.

The work of Mr. Otto Stark and Mrs. Margaret Robertson, U.S. Army Natick Laboratories, in planning and conducting the chromatographic analyses for this study is gratefully acknowledged.

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Abstract

Freeze-dried spaghetti with meat sauce which is used as one of the main components in the Food Packet, Long Range Patrol, was packed with vacuums ranging from 0 to 29 inches and moistures ranging from about 1 to about 5.5 percent. The samples were stored for 24 weeks at 100°F. with withdrawals at 0, 3, 6, 12 and 24 weeks. The products were evaluated by a 10-member technological panel at each withdrawal. Oxygen uptake and carbon dioxide production were determined.

Analysis of variance and regression analysis showed that the moisture level had a significant effect on the panel response and oxygen uptake but contributed only a small part of the variance observed. Increased moisture tended to cause an increase in CO_2 production.

INTRODUCTION

Thompson, et al. (1962) state that three major factors determine the type and extent of deterioration reactions in freeze dried foods: residual moisture, headspace oxygen and duration of storage. Sharp (1953) stored freeze dried raw beef with 1.5, 4.5, and 6.0 percent moisture for 5 months at 59°F. and 99°F. He states that at 59°F. there was very little difference in the stored products. However, at the higher temperature there were definite non-oxidative changes in flavor and texture of the 4.5 and 6.0 percent moisture samples. Olcott (1962) states that partial control of the browning reaction which causes deterioration in freeze dried foods is obtained by low moisture and low temperature storage. Hanson (1961) points out that the lower the moisture content of a dehydrated product, the longer its storage life at high temperatures if oxidation is prevented. However, Salwin (1962) held that the optimum moisture content is not the lowest moisture but corresponds to a theoretical monomolecular layer of absorbed water which with meats would be near or slightly greater than 2 percent moisture. Roth, et al. (1965) in investigations of the deteriorations of freeze dried beef, chicken, carrots, and spinach, reported that the specific biochemical and biophysical properties of each food determine its ability to tolerate some variation in residual moisture, headspace oxygen and duration of storage at elevated temperatures.

Experimental Methods

The spaghetti with meat sauce was made in accordance with Interim Purchase Description IP/DES S-36-6, Food Packet, Long Range Patrol, dated April 20, 1966. Initial dehydration was to less than 2 percent moisture. The vacuum in the chamber was broken with nitrogen. Freeze-dehydration conditions were 120°F. platen temperature with radiant heating and a pressure of 400 microns.

The dehydrated product was adusted to the various moistures desired by calculating the amount of water needed, spraying the water on the product with a paint sprayer while hand mixing, and holding the product under vacuum (27 inches or better) for 48 hours to insure moisture equilibration. The product was then analyzed for moisture and packed 125 grams to a No. 2 1/2 can under various vacuums. It would have been better to freeze dry the product to the exact moisture desired, but the state-of-the-art is not advanced sufficiently to do this at the present time. The canned product was stored at 100°F. for six months with withdrawals at 0,3,6,12 and 24 weeks. Moistures used were 2,3,4 and 5 percent. Vacuums used were 30,26,22,12, and 0 inches. These vacuums correspond to 2, 13,31, 68, and 157 ml of oxygen available per 125 grams of product.

Three cans of each vacuum and moisture were evaluated at each withdrawal. Headspace gas was analyzed for each can, and the product was analyzed for moisture.

Headspace gas analysis was performed by chromatographic means in accordance with the procedure outlined by Bishov and Henick (1966). Prior to analysis the cans were brought to ambient pressure with nitrogen and allowed to equilibrate overnight at ambient temperature. Sample size was 250 - 500 μl. Experience indicates an anticipated error for the method of approximately $\pm$ 0.25 percent.

Total headspace volume in the filled cans was determined by compressing 125 grams of product in a laboratory press at 5,000 lbs. per square inch for 10 seconds and subtracting the volume of the resulting bar from the total volume of the cans. This method is not completely accurate. However, since the volume of headspace gas was so large in comparison with the absolute volume of the product any resulting error was considered insignificant.

Taste panel evaluation was made by a 10 member technological panel rating the product on a 9-point scale for flavor, odor, color and texture where the highest number was the most acceptable. The same panel was used for all evaluations. Product was rehydrated with water at 180°F. for five minutes before tasting. Product in the cans used for chromatographic analysis was used for the panel evaluation.

Results and Discussion

Average panel ratings, oxygen uptake, and actual moisture content of the product are shown in Table 1. Panel ratings are the average of 10 responses and the oxygen uptake is the average obtained from three cans.

Analysis of variance for the taste panel results with factors of vacumm, time and temperature of storage are shown in Table 2. All of the main factors and the 2-factor interactions were significant at the 1 percent level. However, the total degrees of freedom for this analysis was large (999) so that when the percentage of variance assignable to each factor was calculated by the method of Hicks (1956), the moisture was found to have contributed only about 1 percent to the total variance. The interactions with moisture also contributed very little to the total variance. From this it can be concluded that the moisture had a significant effect on the organoleptic changes in the product, but under the conditions of this study storage time and vacuum caused the major part of the observed changes.

Analysis of variance for oxygen uptake and carbon dioxide with the factors of vacuum, time and temperature of storage produced are shown in Table 3. Again, all of the main factors and 2-factor interactions were significant at the 1 percent level. The degrees of freedom in this case were 299. With the oxygen uptake, the moisture contributed very little to the total variance with vacuum, storage time, and the vacuum X storage time interaction contributing over 95 percent. With the CO_2 produced, however, the moisture accounted for an appreciable amount of the total variance.

Multiple linear regression equations were calculated from the data in Table 1 using oxygen uptake as the dependent variable (Y) and percent moisture, time, and vacuum as the independent variables (X_1, X_2 and X_3, respectively). Moisture was found to be nonsignificant at the 5 percent level and the resulting equation was

$$Y = 54.5 + 2.0\ X_2 - 2.5\ X_3$$

The multiple regression coefficient (R_{12}) was 0.8026.

Linear correlation coefficient was calculated for oxygen uptake (X) versus technological results for flavor (Y). Coefficient obtained was 0.684 which while significant at the 1% level is not quite as high as the coefficient determined in another study (Tuomy et al., 1970). However, the regression equation Y + 5.01 - 0.026X is very similar to the one found in that study.

CONCLUSIONS

With freeze-dried spaghetti and meat sauce under the conditions of this study moisture was shown to have a statistically significant effect on the organoleptic deterioration of the product but its contribution to the total was small compared to that contributed by storage time and temperature.

There is enough evidence in the literature and from unreported in-house work to show that moisture does effect freeze-dried foods in general. Its main effect seems to involve browning reactions with meat which, particularly with beef, impart a cooked meat flavor up to a point. Excessive browning results in a bitter flavor and unappetizing color. It is believed that in this study browning reactions did take place, but that the panel did not find the results particularly objectionable.

Table 1. Average oxygen uptake and panel ratings for spaghetti with meat sauce. stored at 100°F

Time (weeks)	Vacuum (in.)	H_2O .93-1.37					H_2O 3.25 -3.86					H_2O 4.12-4.69					H_2O 5.01 -5.49				
		O_2 Uptake	Color	Odor	Flavor	Texture	O_2 Uptake	Color	Odor	Flavor	Texture	O_2 Uptake	Color	Odor	Flavor	Texture	O_2 Uptake	Color	Odor	Flavor	Texture
0	30	0	5.9	6.0	5.3	5.7	0	6.4	6.6	6.1	6.4	0	6.1	6.7	6.4	6.1	0	6.1	6.7	6.4	6.1
	26	0	6.1	6.0	5.5	5.9	0	6.1	6.0	5.7	6.1	0	6.1	6.0	5.9	6.0	0	6.2	6.1	5.9	5.7
	22	0	5.9	6.0	5.3	5.7	0	6.4	6.6	6.1	6.4	0	6.1	6.7	6.4	6.1	0	6.1	6.7	6.4	6.1
	12	0	6.1	6.0	5.5	5.9	0	6.1	6.0	5.7	6.1	0	6.1	6.0	5.9	6.0	0	6.2	6.1	5.9	5.7
	0	0	5.9	6.0	5.3	5.7	0	6.4	6.6	6.1	6.4	0	6.1	6.7	6.4	6.1	0	6.1	6.7	6.4	6.1
3	30	0.9	6.6	6.5	6.6	6.7	1.0	6.4	6.4	6.1	6.0	0.0	6.4	6.1	6.0	6.2	0.4	6.0	5.8	5.5	5.5
	26	6.7	5.1	5.4	5.3	4.8	6.0	5.5	5.4	4.9	5.4	11.0	5.9	5.3	5.2	5.5	0.0	5.2	5.2	4.7	4.6
	22	11.7	5.1	5.7	4.7	6.0	10.0	6.2	5.9	5.8	6.1	14.2	6.3	6.4	6.4	5.9	16.7	5.6	5.5	5.7	6.0
	12	16.4	4.2	4.8	3.6	4.3	16.4	4.8	5.1	3.8	4.6	21.6	4.8	4.7	3.4	5.2	31.4	5.0	4.4	2.9	4.0
	0	42.4	3.6	4.1	2.7	5.1	24.2	3.4	4.7	3.6	5.3	34.2	4.3	5.0	4.1	5.6	40.9	4.0	4.6	4.1	5.2
6	30	1.5	6.3	6.3	6.2	5.8	0.4	5.4	5.8	6.0	5.8	0.7	5.7	5.3	5.1	5.2	1.5	5.7	5.4	5.0	5.6
	26	8.9	5.4	5.3	5.1	5.4	8.2	5.2	5.5	4.9	5.5	17.9	5.2	5.3	4.9	5.0	10.5	6.5	5.5	5.0	4.9
	22	17.5	4.4	4.9	4.3	5.4	16.4	5.4	4.9	4/2	5.3	24.7	5.5	5.2	5.4	5.7	24.4	5.7	5.4	5.0	5.8
	12	29.1	3.7	4.1	3.3	4.8	30.6	4.5	4.6	4.1	5.2	41.8	4.5	4.3	3.8	4.8	60.6	6.1	4.9	3.5	4.6
	0	110.6	2.6	1.9	1.4	3.0	38.9	2.6	3.4	2.7	4.6	63.0	3.4	3.4	2.7	4.6	71.3	3.5	3.3	2.6	4.9
12	30	0.9	6.6	6.4	5.8	6.0	1.0	5.8	5.7	5.5	5.9	0.3	5.9	4.4	3.9	5.0	0.7	5.7	4.2	3.8	4.9
	26	10.4	5.6	5.6	5.1	5.6	14.2	5.4	4.9	4.3	4.7	20.2	5.2	4.5	3.5	4.7	11.3	4.1	3.5	3.4	4.3
	22	26.9	4.8	5.2	4.6	4.9	30.4	5.8	5.1	3.9	5.4	34.4	4.3	4.4	3.5	5.1	33.9	3.7	4.0	3.1	4.8
	12	56.9	2.6	3.0	2.2	4.4	53.1	4.2	3.5	2.9	5.0	71.7	5.0	3.4	2.9	4.7	80.8	4.0	3.2	2.4	4.5
	0	147.8	2.8	2.7	1.9	4.0	91.4	2.8	3.0	2.3	4.9	114.9	3.3	2.8	2.3	3.8	123.6	4.4	3.7	3.0	4.2
24	30	2.1	6.9	6.3	6.2	6.3	1.7	5.5	4.8	4.8	5.1	2.0	3.5	3.8	2.7	4.0	1.7	3.4	3.6	2.7	4.2
	26	14.9	4.1	4.8	3.9	5.1	2.2	5.0	4.1	3.4	5.4	0.0	2.3	2.9	2.3	3.9	4.5	1.9	3.0	2.3	4.1
	22	14.2	4.1	4.6	3.8	5.3	36.3	6.0	5.0	4.0	5.0	35.9	4.4	4.2	3.6	4.3	34.6	3.5	3.2	2.4	3.9
	12	80.0	1.0	1.0	1.0	1.0	62.0	3.6	2.6	2.2	4.2	38.1	3.0	2.6	2.0	2.3	82.3	1.0	1.0	1.0	1.0
	0	148.8	3.2	3.0	2.8	4.7	148.8	4.6	3.7	2.9	5.2	148.8	4.0	3.3	3.0	4.5	149.5	3.2	2.6	2.3	4.1

Table 2. Analysis of variance results and percent of total variance assignable to factors for oxygen uptake and carbon dioxide produced.

FACTOR	O_2 Uptake		CO_2 Produced	
	SIG	%	SIG	%
A (H_2O)	XX	0.4	XX	19.1
B (TIME)	XX	24.3	XX	38.7
C (VAC)	XX	42.3	XX	6.5
AB	XX	0.4	XX	15.8
AC	XX	2.0	XX	4.9
BC	XX	28.9	XX	5.8
REM	-	1.7	-	9.2

XX - Significant at the 1 percent level.

DF = 299

Table 3. Analysis of variance results and percent of total variance assignable to factors for panel ratings.

FACTOR	COLOR		ODOR		FLAVOR		TEXTURE	
	SIG.	%	SIG.	%	SIG.	%	SIG.	%
A(H_2O)	XX	1.1	XX	1.0	XX	0.7	XX	2.6
B (TIME)	XX	21.9	XX	34.5	XX	34.1	XX	19.0
C (VAC)	XX	15.2	XX	14.8	XX	17.9	XX	9.2
AB	XX	6.8	XX	2.8	XX	3.5	XX	2.8
AC	XX	4.8	XX	2.5	XX	3.6	XX	2.9
BC	XX	11.2	XX	7.9	XX	8.3	XX	9.4
REM	-	39.0	-	36.5	-	31.9	-	54.1

XX - Significant at the 1 percent level.

DF= 999

References

1. Bishov, S. J. and A. S. Henick. 1966. A gas chromatograph method for continuous accelerated study of O_2 uptake in fats. J. Am. Oil Chemists" Soc. 43, 477.

2. Hanson, S. W. F. (ed.). 1961. The Accelerated Freeze-Drying Method of Food Preservation. H. M. Stationery Office, London.

3. Hicks, C. R. 1956. Fundamentals of analysis of variance. Part II. The components of variance model and the mixed model. Ind. Qual. Control. 13 (No. 3), 5.

4. Olcott, Harold S. 1962. Deteriorative reactions in stored freeze-dried meat and fish, in "Freeze-Drying of Foods." (F. R. Fisher, ed.), National Academy of Sciences - National Research Council, Washington, D.C.

5. Roth, N., R. Wheaton, and P. Cope. 1965. Effect of exposure to oxygen on changes in meats and vegetables during storage. Contract No. DA19-129-AMC-131(N), U. S. Army Natick Laboratories.

6. Solwin, Harold. 1962. The role of moisture in deteriorative reactions of dehydrated foods, in "Freeze-Drying of Foods," (F. R. Fisher, ed.), National Academy of Sciences--National Research Council, Washington, D.C.

7. Sharp, J. S. 1953. Dehydrated Meat. H. M. Stationery, London.

8. Thompson, J. S., J. B. Fox, Jr., and W. A. Landmann. 1962. The effect of water and temperature on the deterioration of freeze-dried beef during storage. Food Technol. 16, 131.

9. Tuomy, J. M., L. C. Hinnergardt, and R. L. Helmer. 1970. Response of cooked freeze-dried combination items to oxygen. U. S. Army Natick Laboratories. Report No. 70-64-FL.

UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author)

U. S. ARMY NATICK LABORATORIES
Natick, MA 01760

2a. REPORT SECURITY CLASSIFICATION

UNCLASSIFIED

2b. GROUP

3. REPORT TITLE

Effect of Moisture on the Quality of Freeze-Dried Spaghetti with Meat Sauce.

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

J. M. Tuomy and L. C. Hinnergardt

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
October 1970	7	9

8a. CONTRACT OR GRANT NO.

b. PROJECT NO. 1J662708D553

c.

d.

9a. ORIGINATOR'S REPORT NUMBER(S)

71-26 FL FL- 122

9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

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11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY

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13. ABSTRACT

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Analysis of variance and regression analysis showed that the moisture level had a significant effect on the panel response and oxygen uptake but contributed only a small part of the variance observed. Increased moisture tended to cause an increase in CO_2 production.

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Moisture Content	6		2			
Oxygen	6		2			
Headspace Gas	6		2			
Field Rations	7		1			
Freeze Dried Foods	7		1			
Spaghetti	7		1			
Meat Sauce	7		1			
Cans	7					
Analysis			8			
Carbon Dioxide			2			
Taste Tests			8			

Unclassified
Security Classification